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National Apprenticeship and Training Standards for Drafters

U. S. Department of Labor
Employment and Training Administration

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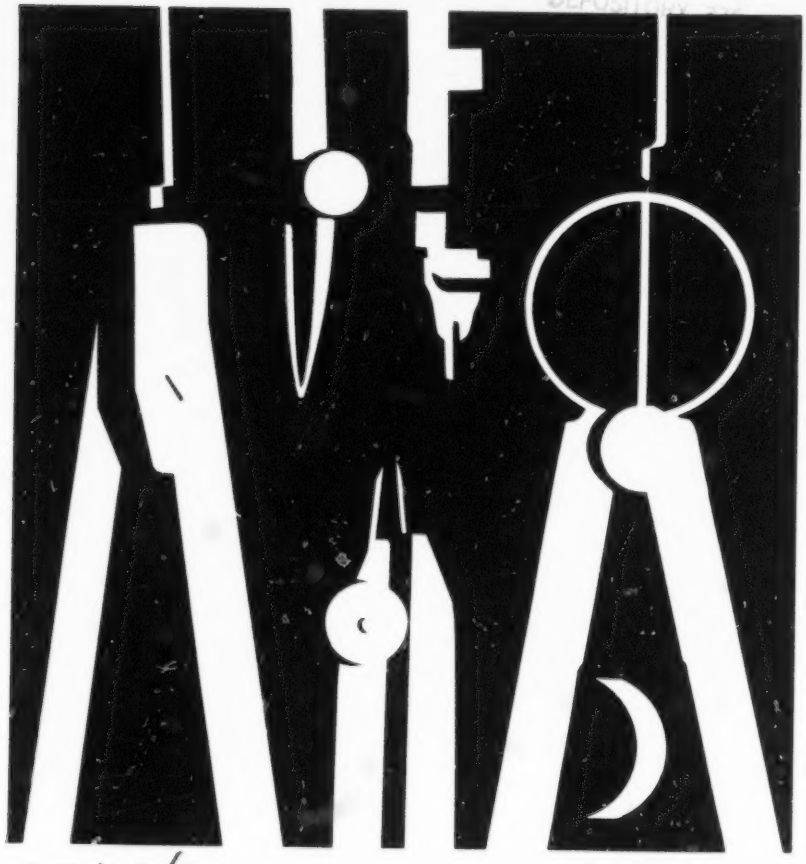

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National Apprenticeship and Training Standards for Drafters

U.S. Department of Labor
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Bureau of Apprenticeship and Training
Revised 1982

PREFACE

Set forth on the following pages are the revised national apprenticeship and training standards for the training of drafters as developed and recommended by the International Federation of Professional and Technical Engineers, AFL-CIO, in cooperation with the Bureau of Apprenticeship and Training, U.S. Department of Labor.

Through the concerted interest of management and labor in training, the industry can maintain and improve its supply of skilled workers. The standards provide a common basis for the mutual undertaking of the training that will benefit employers, employees, and the public.

The sponsor hopes that these standards will be considered in the spirit in which they were conceived, to improve the quality and opportunities of drafters through the establishment of uniform training programs.

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INTRODUCTION

The Problem

The term "engineering drawing" defines "drawing" as it is used in the industrial world by engineers and designers. It is the graphic language which expresses and records the ideas and information needed to build machines and structures. Engineering drawing is distinguished from fine-arts drawing as practiced by artists in pictorial representation. Drafters have a greater task. They may not simply suggest their meaning but must give exact and positive information on every detail of the machine or building to be constructed. Thus drawing is more than pictorial representation to them; it is a complete graphical language, which describes minutely every necessary operation and forms a complete record of the work for duplication or repairs.

In nearly all engineering departments there are several classifications of drafters with varying qualifications, duties, and compensations. For example, a drafter in one company may mean a detailer, and in another, a designer. For the purposes of these standards the following definition is given:

> A *drafter* is one who has sufficient knowledge and training to break down design layouts with a minimum of instruction as to function; to make detailed drawings of all parts, establishing practical dimensions, materials, and materials treatment; and to develop assembly and subassembly drawings as required.

Competent drafters are needed to link the designer with the skilled mechanic. In some respects their training parallels that of the mechanic in the development and coordination of hand and eye skills. Coupled with hand skill must be technical knowledge of sciences and mechanics if the engineer's ideas are to be interpreted and successfully followed.

The definition above implicitly limits the scope of the related instruction that should be part of these apprenticeship and training standards. These courses (appendix) were selected not only to train apprentices to become drafters, but also to lay the groundwork for studies leading to certification in design or engineering and eventually to license as a registered engineer, marine architect, or architect, should the apprentice have the aptitude, initiative, and persistence to pursue it.

Technological advances are rapidly changing the drafting field. In recent years, the "age of the computer" has extended our ability to communicate. Computer technology will enable drafters to reach new creative heights.

Various automatic drafting systems exist today; they will become more sophisticated in the future. The electronic pen, surrounded by computer screens and key boards, is an automated system that represents a forward step for drafting. Computerized systems permit the designing, defining, and delineating of geometry with an ease and accuracy far beyond traditional methods. Once established, a data base of assembly parts may be used in many ways to serve many people. The computer at present helps design, redesign, and evaluate. It can also assemble, stack parts, create numerical control tapes, lathe templates, inspection templates, obtain mass properties, define and calculate finite elements for stress and heat transfer analysis.

Apparently, computerized drafting systems are limited only by engineering imagination and operator experience. A rapid rise in the employment of drafters is expected as a result of the increasingly complex design problems presented by modern processes and products. As engineering and scientific occupations grow, more drafters will be needed as supporting personnel. On the other hand, expanding use of electronic drafting equipment and computers is eliminating many routine tasks, a development that probably will reduce the need for less skilled drafters.

To the concept of the continuing improvement of a skilled workforce the International Federation of Professional and Technical Engineers dedicates its best efforts.

RESPONSIBILITY FOR TRAINING

Skilled workers and technicians are trained in many different ways. Their training may be acquired in formal programs, informally, or in both ways. It may take the form of apprenticeship or enrollment in a technical institute or in a community or junior college. It may occur through observation and imitation or planned instruction on the job. It may involve study in a night school class or through a correspondence course. The very diversity of the ways in which people can acquire skill is a source of strength to the Nation.

The International Federation of Professional and Technical Engineers recognizes its obligation to industry and the

Nation. It is its sincere belief that skilled workers who are the product of apprenticeship have been prepared for an occupation rather than for a specific job. They are likely to be better equipped to meet the challenge of new problems. A formal training program which is not narrowly centered on meeting immediate production needs will provide the employer with more resourceful and adaptable workers.

The distinctive abilities and competence of skilled workers are not quickly acquired. The time necessary to prepare individuals for skilled jobs is affected by many factors. Their aptitudes, background, the amount and quality of their schooling, and their access to training opportunities must all be taken into consideration.

It is from this viewpoint that these apprenticeship and training standards are proposed. All local unions are urged to use these standards as a guide in establishing local programs of apprenticeship and training.

PROVISIONS OF STANDARDS FOR DRAFTERS[1]

1. Definitions

a. *Employer* shall mean any employer who subscribes to the terms and conditions prescribed by the local joint apprenticeship and training committee and who has the facilities and equipment to train an apprentice properly.

b. *Union* shall mean any local union of the International Federation of Professional and Technical Engineers, AFL-CIO.

c. *Apprentice* shall mean a person who is under an apprenticeship agreement to learn drafting as outlined in these standards and who is registered with the registration agency.

d. *Apprenticeship agreement* shall mean a written agreement between an employer and an apprentice, approved by the committee; or between the apprentice and the committee, acting as agent of the employer.

e. *Committee* shall mean the local joint apprenticeship and training committee, usually composed of three members representing the employers and three members representing the union.

f. *Registration agency* shall mean the recognized State apprenticeship agency, or in States where no such agency exists, it shall mean the Bureau of Apprenticeship and Training, U.S. Department of Labor.

2. Qualifications for Application

a. There are no age restrictions. The program, however, requires substantial amounts of classroom work. Most successful apprentices join the program within five years of their high school graduation.

b. Applicants for apprenticeship shall have sufficient aptitude to master the related technical instruction required, as evidenced by the ability to pass an aptitude

[1]Local application of the national apprenticeship and training standards in States having State apprenticeship councils may require adaptations to meet the standards of apprenticeship in such States. The staffs of the Bureau of Apprenticeship and Training or State apprenticeship agencies are available to assist local program sponsors in meeting standards requirements.

test administered by the local office of the State employment service.

c. Applicants must be physically able to perform their duties, as determined by a doctor's examination.

3. **Selection**

a. The recruitment, selection, employment, and training of apprentices during their apprenticeship shall be without discrimination because of race, color, religion, national origin, or sex. The sponsor will take affirmative action to provide equal opportunity in apprenticeship and will operate the apprenticeship program as required under title 29 of the Code of Federal Regulations, part 30, as amended.

b. Local program sponsors may establish additional qualifications as desired or deemed necessary. Such qualifications must be specific, clearly stated, and directly related to job performance.

In addition to establishing qualification standards, each local program sponsor employing five or more apprentices will be required to develop and adopt an affirmative action plan, which shall include goals and timetables if analysis indicates underutilization of minorities, and shall adopt a selection method consistent with the requirements of title 29, CFR, part 30, as amended.

c. Local program sponsors employing fewer than five apprentices are required only to adopt the equal employment opportunity pledge stated in **3a** above.

Criteria or standards used by local program sponsors to measure progress in training, satisfactory completion of apprenticeship, or allowable credit for previous work must be related to job performance and applied equally to all apprentices.

4. **Credit for Previous Experience and Education**

If the local joint apprenticeship and training committee finds, upon examining the applicant's records, that the applicant has had previous practical experience and/or education, it may recommend advanced standing on the term of apprenticeship. Such advanced standing will be subject to review by the committee at or before the end of

the probationary period. Where advanced standing on the term of apprenticeship is granted apprentices, they will be paid the rate of the period to which they are advanced.

5. Term of Apprenticeship

a. The term of apprenticeship for drafters in the manufacturing and in the construction industry shall be not less than 4 calendar years, or sixteen 3-month, twelve 4-month, or eight 6-month periods, of reasonably continuous employment.

b. The probationary period shall be included in this term.

c. The term of apprenticeship may be extended up to 1 year upon mutual agreement of the union and management.

6. Apprenticeship Agreement[2]

a. Each apprentice shall be covered by a written agreement and registered with the appropriate registration agency.

b. Each apprenticeship agreement entered into under local programs conforming to these national standards shall contain:

(1) The name and signatures of the contracting parties.

(2) The place and date of birth of the apprentice.

(3) The date on which the apprenticeship shall begin and the time of its duration, together with any credit granted on such term of apprenticeship.

(4) A statement that the apprentice shall have the benefit of experience, in all the elements of drafting.

(5) A statement making the terms and conditions of the local apprenticeship and training standards a part of the agreement.

7. Supervision

Each employer shall designate as supervisor of apprentices a particular person, whose duties — in addition to

[2]Some State apprenticeship agencies require the use of their own apprenticeship agreement forms. In such instances, the agreement forms may be obtained from the staff of the State apprenticeship agency or the Bureau of Apprenticeship and Training.

those noted herein — shall be defined by the local committee.

8. Probationary Period

a. Apprentices shall be subject to a tryout or probationary period, to be governed by the collective bargaining agreement or to be determined by the local joint apprenticeship and training committee. Such period shall not exceed 6 months of reasonably continuous employment.

b. During the probationary period, the termination or cancellation of the apprenticeship agreement may be made by the local joint apprenticeship and training committee at the request of either party to the agreement. After the probationary period, the committee may cancel the agreement for due cause, such as lack of progress or lack of interest, and all parties to the agreement have had an opportunity to be heard.

c. The registration agency shall be advised of all cancellations and terminations of apprenticeship agreements.

9. Hours of Work

The workday and workweek for apprentices and conditions associated therewith shall be the same as those of other drafters doing comparable work.

10. Salaries

a. The local apprenticeship standards shall state that the salary schedule for apprentices shall be governed by the appropriate collective bargaining agreement and preferably expressed as a progressive percentage of the drafter's salary.

b. The successive step increases shall preferably be at 3-month, 4-month, or 6-month intervals.

c. Apprentices who receive credit for previous experience shall be paid, upon entrance, the salary of the period to which such credit advances them.

d. When credit is granted at some time subsequent to the start of the apprenticeship, apprentices shall be advanced to the salary of the period in which such credit places them.

11. Examinations

The committee may examine the work and school records of apprentices before each period of advancement and at such other times as it may determine. In lieu of an examination, a written report of successful progress from the supervisor of apprentices may be accepted by the committee. The committee shall give consideration to school and on-the-job work and such other items as are indicative of the apprentices' development and make such recommendations as it considers desirable.

12. Related Instruction

a. Each apprentice shall enroll in, and attend regularly, such related technical instruction courses in an approved educational institution as are prescribed for apprentices. (See appendix for recommended courses; wherever possible, such courses shall be acceptable for college credit.)

b. Apprentices may be required to attend courses during or outside of the regular working hours, depending upon local practices and available facilities.

c. Time spent in attending such courses after working hours shall not be considered as hours of work; but if apprentices are required to attend courses during the regular working hours, they shall be compensated therefor at their regular hourly rates.

d. It is recommended that, if apprentices are required to attend courses for which tuition and material fees and costs are charged, they shall be reimbursed by their employer upon condition that they complete such courses with a passing grade.

e. In case of failure, without good cause, on the part of apprentices to fulfill the obligations as to the progressive and satisfactory completion of the courses of related technical instruction and the work schedule as required, the committee may suspend or revoke the agreement. The committee shall notify the registration agency of such suspension or revocation and the reason therefor.

f. The local joint apprenticeship and training committee may obtain assistance in formulating, adopting, and funding related technical instruction classes from

the Division of Vocational and Technical Education, U.S. Department of Education, which administers and supervises Federal funds appropriated for apportionment among the States for apprentice and journeyman training. Assistance may also be received from State and local boards of vocational education.

13. Ratio

The ratio of apprentices to other technical employees shall be mutually agreed upon or fixed according to local needs incorporated into local collective bargaining agreements. The optimum ratio is dependent on the rate of expansion of technological activity and on the rate of withdrawals from the roster of technical employees by virtue of promotion to higher classifications, including supervisory positions, and retirements. Provision should be made for periodic review of the specified ratio to cover special circumstances.

14. Work Experience

a. Apprentices shall be taught the use, care, and effective handling of all tools and equipment commonly used in connection with drafting.

b. They shall be given the instruction and experience necessary to develop the skills, theory, and practice of drafting. They shall perform all duties commonly related to drafting apprenticeship. (See the appendix for recommended work-experience schedules.)

c. If the employer's facilities and arrangements do not permit giving the apprentice machine shop experience in the plant, then such shop instruction should be arranged for in the local vocational school.

15. Management and Labor Relations

a. *Adjusting differences.* — In case of dissatisfaction between the employer and the apprentice, either party may appeal to the local joint apprenticeship and training committee for action and adjustment of such matters as come within the scope of the apprenticeship and training program or avail themselves of the grievance procedure of the collective bargaining agreement.

b. *Relation of these standards to the collective bargaining agreement.* — No provisions of the apprenticeship and training program shall supersede the terms and conditions established in the collective bargaining agreement.

16. Equal Opportunity

All programs of apprenticeship registered with the Bureau of Apprenticeship and Training, U.S. Department of Labor, or recognized State apprenticeship agencies must include in their program the following equal opportunity pledge:

> The recruitment, selection, employment, and training of apprentices during their apprenticeship shall be without discrimination because of race, color, religion, national origin, or sex. The sponsor will take affirmative action to provide equal opportunity in apprenticeship and will operate the apprenticeship program as required under title 29, of the Code of Federal Regulations, part 30, as amended.

SUPERVISION OF THE PROGRAM

1. Local Joint Apprenticeship and Training Committee

In order to obtain the maximum effectiveness in apprenticeship and training programs, a local joint apprenticeship and training committee should be established, equally representative of the employer and the union. It may add to its members equal representation from the employer and the union at its discretion.

a. *Administrative Procedure*

(1) The committee shall elect a chairman and secretary. It shall determine the time and place of meetings.

(2) The chairman and secretary shall vote on all questions.

(3) When the chairman is a representative of the employer, the secretary should be a representative of the union, and vice versa.

(4) The committee shall establish such rules and regulations governing its administrative procedures as are required.

b. *Duties of the Committee*

(1) To ascertain the feasibility of training apprentices in the plant of the employer, taking into account the available facilities for providing apprentices with the necessary experience on the job.

(2) To establish minimum standards of education and experience for the apprentice.

(3) To place apprentices under agreement and to submit these agreements, or evidence thereof, to the appropriate registration agency.

(4) To cooperate with the supervisor of apprentices in his responsibilities toward apprentices, the employer, and the committee.

(5) To hear and adjust all differences pertaining to apprenticeship between apprentices and the employer when such adjustments are not covered by a working agreement.

(6) To determine the apprentices' progress in

manipulative skills and technical knowledge through periodic review of their records.

(7) To make annual reports covering the work of the committee to the employer and the union.

(8) In general, to be responsible for the sucessful operation of the apprenticeship and training program by performing the duties listed above.

2. Responsibilities of Apprentices

Apprentices should clearly understand that, in signing the apprenticeship agreement, they have voluntarily agreed to abide by the provisions of the local standards. The committee should inform apprentices of their responsibilities and obligations under the apprenticeship program, as follows:

a. To perform diligently and faithfully the duties assigned by the local joint committee and the employer in accordance with the provisions of the standards.

b. To respect the property of the employer and abide by the working rules and regulations of the employer, union, and local joint committee.

c. To attend regularly and complete satisfactorily the required courses of related instruction as provided under the local standards.

d. To maintain such records of work experience and training received on the job and in related instruction as may be required by the local joint committee.

e. To develop safe working habits and conduct themselves in their work in such manner as to assure their own safety as well as that of their fellow workers.

f. To work for the employer who is assigned to the completion of their apprenticeship, unless they are reassigned to other employers or their agreement is terminated by the local joint committee.

g. To conduct themselves at all times in a creditable, ethical, and moral manner, realizing that much time, money, and effort will be spent in affording them an opportunity to become skilled drafters.

3. **Consultants to the Committee**

   a. Consultants to the committee may be from the Bureau of Apprenticeship and Training, U.S. Department of Labor, State apprenticeship agencies, and/or State departments of education.

   b. Consultants to the committee should attend meetings only upon request of the committee; advise the committee on problems affecting the agency they represent; and provide assistance which will help improve the apprenticeship and training programs.

4. **Recognition of Completion of Apprenticeship**

   a. When apprentices have successfully completed their apprenticeship, the committee shall recommend that they be presented a certificate of completion of apprenticeship, which may be furnished by registration agency upon request.

5. **Filing With the Registration Agency**

   As soon as local apprenticeship standards, or any amendments thereto, have been developed and approved by the local sponsoring groups, the local joint committee shall file a copy with the registration agency.

6. **Safety and Health Training**

   The employer shall instruct the apprentice in safe and healthful work practices, and shall ensure that the apprentice is trained in facilities and in other environments that are in compliance with either the occupational safety and health standards promulgated by the Secretary of Labor under Public Law 91-596, dated December 29, 1970, or State standards that have been found to be at least as effective as the Federal standards.

7. **Modification of Standards**

   These national standards may be modified at any time by the International Federation of Professional and Technical Engineers, AFL-CIO, national office. Such modification shall be submitted to the National Office of the Bureau of Apprenticeship and Training, U.S. Department of Labor, for approval.

Local programs may be modified by the local joint apprenticeship committee, and must be submitted to the appropriate registration agency for approval.

Modification of local programs shall not adversely affect apprenticeship agreements in effect at the time of the modification.

FEDERAL LAWS AND REGULATIONS AFFECTING THE EMPLOYMENT OF APPRENTICES

1. Veterans Readjustment Legislation (Public Law 90-77, 90th Congress)

A veteran of at least 181 days of continuous active duty, any part of which occurred after January 31, 1955, or a veteran who was released from active duty after January 31, 1955, for a service-connected disability is eligible to pursue on a full-time basis an approved program of apprenticeship and receive a monthly training assistance allowance.

The apprenticeship program must meet the standards of the Bureau of Apprenticeship and Training, U.S. Department of Labor, and be approved by the appropriate State veterans approving agency.

Under the provisions of the veterans readjustment legislation, joint apprenticeship committees may be recognized as training establishments.

2. Wage and Hour Regulations (Ruling Concerning Payment for Time Spent by Apprentices in Related Instruction)

The Fair Labor Standards Act requires that each employee, not specifically exempted, who is engaged in interstate commerce or in the production of goods for such commerce receive the statutory minimum wage and that no employee (including an apprentice) may be employed for more than 40 hours a week without receiving at least time and one-half of the regular rate of pay for the overtime hours.

As an enforcement policy, time spent in an organized program of related supplemental instruction by apprentices working under bona fide apprenticeship programs may be excluded from working time if the following criteria are met: (1) The apprentice is employed under a written apprenticeship agreement or program which substantially meets the basic standards of the Bureau of Apprenticeship and Training, U.S. Department of Labor, and (2) such time does not involve production work or performance of the apprentice's regular duties. If the above criteria are met, the time spent in such re-

lated supplemental training shall not be counted as hours worked unless the written agreement specifically provides that it is hours worked. The mere payment or agreement to pay for time spent in related instruction does not constitute an agreement that such time is hours worked.

3. Equal Employment Opportunity Legislation and Regulations

The Civil Rights Act of 1964, title VII, prohibits discrimination in all phases of employment, including apprenticeship, because of race, color, religion, sex, or national origin. It applies to employers; employment agencies; labor organizations; joint apprenticeship committees; and, under the 1972 amendments, Federal agencies.

Detailed information regarding application of title VII of the Civil Rights Act may be obtained from the Regional Offices of the Equal Employment Opportunity Commission.

Title 29, Code of Federal Regulations, part 30, as amended April 8, 1971, requires that programs of apprenticeship registered with the U.S. Department of Labor, or with a State apprenticeship agency recognized by the Department as the appropriate registration agency for registering programs for Federal purposes, include in the standards the equal opportunity pledge stated in the regulation. The pledge provides for the recruitment, selection, employment, and training of apprentices during their apprenticeship without discrimination because of race, color, religion, national origin, or sex.

The regulation further requires that each apprenticeship program sponsor who employs five or more apprentices adopt an appropriate apprentice selection method and affirmative action plan, including goals and timetables if analysis indicates deficiencies in the utilization of minorities in the program.

Detailed information regarding the application of nondiscrimination requirements under title 29, CFR, part 30, as amended, may be obtained from the Bureau of Apprenticeship and Training, U.S. Department of Labor, or the recognized State apprenticeship agency.

APPENDIX: SCHEDULES OF RECOMMENDED WORK PROCESSES AND RELATED TECHNICAL INSTRUCTION

DRAFTER (MANUFACTURING)

Work Schedule

Assignment	Approximate months
A. Tracing and Routine Department Work	3
B. Elementary Drafting	3
C. Detailing and Engineering Changes	12
D. Machine Drafting and Simple Design	12
E. Advanced Drafting and Tool Design	12
F. Subassembly and Assembly Drawings	6
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The above schedule of training shall be followed whenever practicable; however, adjustments may be made to accommodate the schedule to local conditions.

Related Instruction

First Year

1st Semester

Drafting I

Proficiency in lettering, care and use of instruments, drafting room standards and convention. Theory of orthographic projection, reading problems, freehand sketching, pattern and foundry work, and machining operations affecting design and details; isometric sketching and tracing of various drawings.

2d Semester

Drafting II

Making working drawings complete with dimensions of shop objects; solving problems involving sections, auxiliary views, screw fasteners, springs, and threaded parts. Special attention given to accurate dimensioning systems, including decimal limits, trimetric drawings, and layout drawings.

Second Year

1st Semester

Detailing Design

Basic design of machine parts. Materials and methods; cast, forged, and welded parts; shafts, bearings, and seals; mating parts and tolerances; complete set of details and assembly of a simple machine; use of empirical formulas.

Intermediate Algebra

Review of elementary algebra in addition to covering equations and systems of equations of first-degree exponents and radicals, factoring, and an introduction to quadratic equations.

2d Semester

Advanced Drafting and Design

Includes intersections and developments; machine elements such as spur gears, bevel gears, worm gears, cams, cam followers, motions and empirical design of various elements common in machine construction.

College Algebra

The system of real numbers and the basic laws governing operations with numbers. Linear and quadratic equations, functions, and graphs; systems of equations, exponents and the exponential function; logarithms, variations, progressions.

Third Year

1st Semester

Advanced Drafting (continuation)

Descriptive Geometry I

Fundamental theory of point, line, plane.

Trigonometry

The trigonometric functions and their application in problems of surveying and mechanics, including the solution of right and oblique triangles with and without the use of logarithms. Identities and trigonometric equations, functions of the sum and difference of two angles, double and half-angle formulas.

2d Semester

Tool Design

Elementary problems in tool design, featuring the design of jigs for drilling, reaming, and duplicating machine parts, as well as fixtures for milling, boring, and other machine operations. At least one example of punch and die design.

Descriptive Geometry II

Continuation of Descriptive Geometry I above. Intersections of various geometric shapes and developments as they apply to sheet metal and machine parts; trimetric projection.

Analytical Geometry

Rectangular coordinates; distance formula; slope; angle between two lines; equations of the line; circle, parabola, ellipse, and hyperbola; transformation of coordinates; algebraic curves of special interest; trigonometric and exponential curves.

Fourth Year

1st Semester

Elementary Statics

Application of the laws of external equilibrium. Forces on bars, beams, trusses. Internal equilibrium, cords, links. Shear and moments in beams.

2d Semester

Elementrary Strength of Materials

Internal equilibrium, normal shear stresses, properties of materials, Hooke's Law. Linear stress distribution in shafts, beams, and columns. Twist of shafts, deflection of beams, redundant beams.

Introduction to Computer-Aided Drafting Systems

DRAFTER (MARINE)

Work Schedule

Assignment		Approximate months
A. Mold Loft		6
B. 1. Shipfitting		3
2. Pipefitting		3
3. Electrical		3
4. Sheet Metal and Plate Shop		3
C. 1. Shipfitting	6 mos.	
or	or	
2. Pipefitting	6 mos.	6
or	or	
3. Electrical	6 mos.	
D. Tracing and Routine Dept. Work		6
E. Alterations		6
F. Detailing		12
		48

Related Instruction

First Year

1st Semester

Nomenclature of Naval Vessels

Ships and ship terms, shipbuilding materials, structural routing of plans and materials, mold loft, fabrications, hull structure, welding, launching, engineering, outfitting safety, ship terms and their meanings.

Drafting

Theory of orthographic projection, reading problems, freehand sketching, conventional representation, sections, pattern and foundry work, and machining operations affecting design and details. Isometric sketching, engineering lettering, springs, threads, fasteners.

2d Semester

Technical Mathematics I

The slide rule (or calculator) and scientific notation and their use in technical calculations. Selected topics of algebra and mensuration and their engineering applications; industrial practice including algebraic operations, grouping, and factoring; mensuration of areas and volumes of simple and composite figures.

Detailing Design

Basic design of machine parts for ease and economy of manufacture. Materials and methods; cast, forged, and welded parts; shafts, bearings, and seals; mating parts and tolerances; latches, locks, and fastenings; machine accessories; operating linkages; use of empirical formulas.

Second Year

1st Semester

Technical Mathematics II

Mathematical requirements for mechanics, strength of materials, kinematics, heat transfer, and design courses. Includes trigonometry, continuation of algebra for technical analysis, slide rule applications, and use of special scales.

Descriptive Geometry

Practical problems covering planes and lines, revolutions, intersection of surfaces, developments, etc.

2d Semester

Technical Mathematics III

Study of quadratics, logarithms, complex numbers, vec-

tors and oblique triangles.

Fundamentals of Marine Drafting

Lines and molded offsets, contract plans, body plan, half-breadth plans, profile, scantlings, and sight edges. Specifications of ship and materials, compartmentation and arrangements, shell expansions, keel, stem, floors, longitudinals, frames, decks, bulkheads, foundations, location and design and detail, welding, and riveting.

Third Year

1st Semester

Marine Engineering I

Introduction to naval engineering, the naval ship, ship stabilities, and damage control. Basic principles of steam engineering, naval boilers, boiler fittings, and instruments.

Material and Processes

A study of manufacturing, processes, selection of materials commonly used in industry (metallic and nonmetallic), analysis of the control of properties, heat treatment, testing, and inspection.

2d Semester

Marine Engineering II

Combustion requirements, steam turbines, condensate and feed systems, pumps and valves, lubrication, reduction gears, bearings, shafting, and propellers, distilling plants, refrigeration and air conditioning.

Graphic Statics

The graphic representation of forces and stresses, analysis of stress in trusses, beams, girders, and machine members with application to practical problems. Study of friction, sliding, journal, and rolling.

Fourth Year

1st Semester

Marine Engineering III

Additional engineering equipment, the engineering plant, internal combustion engines, fundamentals of electricity, shipboard electrical systems.

Mechanics

Study of equilibrium of forces, simple machines, friction force and acceleration, work energy, power, centroids, and moments of inertia.

2d Semester

Marine Engineering IV

Fundamentals of nuclear physics, reactor principles, the naval nuclear power plant, engineering department organization and administration.

Strength of Materials

Study of stress, strain, shear, and moment diagrams for beams, beam deflections, torsion, flexure, riveted and welded joints, columns, and combined stresses.

Introduction to Computer-Aided Drafting Systems

DRAFTER (ARCHITECTURAL)

Work Schedule

First Year

1. Tracings and routine department work.
2. Tracing of drawings, following special instructions as to methods and detail. Simple architectural details.
3. Making minor alterations to drawings or tracings, transcribing of same, and following instructions as to views, projection, and sections.
4. Drawing of simple construction details. Visits to jobs to learn application.

Second Year

5. Design of simple architectural motifs. Advanced structural details. Advanced materials study and their uses and limitations.
6. Developing preliminary drawings and relating suggested specifications to same for consultation purposes. Job visits to observe application of principles.

Third Year

7. Developing working drawings, integrating known specifications into them; preparing preliminary estimates for them; minor job supervision.

Fourth Year

8. Developing working drawings, including rough layout of mechanical trades involved; designing of structures; supervising of jobs in progress and preparing report on same. Preparing prebid cost estimates.

Related Instruction

First Year

1st Semester

Drafting

Theory of orthographic projection, reading problems, freehand sketching, conventional representation, sections, isometric sketching, architectural lettering.

Art-Life Drawing

Pencil and charcoal sketching; various methods of pictorial representation; techniques of making illustrations attractive.

2d Semester

Drafting

Special attention to layout drawings, architectural pencil and ink tracings.

Second Year

Detailing Design

Basic Greek and Roman architecture.

Introduction to Engineering Mathematics

Technical Illustration

Pictorial representation techniques, introduction to water color.

Third Year

1st Semester

Descriptive Geometry

Trigonometry

2d Semester

Advanced Descriptive Geometry

Analytical Geometry

Fourth Year

1st Semester

Strength of Materials

2d Semester

Estimating

Basic Building Codes